Technical Guidelines for Ontario’s Air Quality Health Index Plus and the Associated Advisory Program

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and

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### Introduction

The Air Quality Index (AQI) program of Ontario Ministry of the Environment, Conservation and Parks (MECP) was established in 1988 to provide the public with continuous information on ambient air quality. The AQI program originally included ozone (O3), nitrogen dioxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), suspended particles (SP) and total reduced sulphur (TRS) compounds. On August 23, 2002, MECP replaced SP in the AQI with fine particulate matter (PM2.5), making Ontario the first province in Canada to do so. In association with the AQI program, MECP launched the Air Quality Advisory program in 1993. This program was expanded in 2000 to the Smog Alert program under which smog advisories were issued. In 2021, MECP operates an extensive network of 39 ambient air quality monitoring sites across the province.

In 2006, Health Canada proposed the Air Quality Health Index (AQHI), an index that derives a value based on the cumulative effects of three pollutants: O3, NO2, and PM2.5. It is being developed and implemented by Health Canada with the assistance of Environment and Climate Change Canada (ECCC) and all provinces. The AQHI informs the public about health risks associated with air quality and encourages the public to make their own decisions or modify their behaviour depending on how they are individually affected by air quality. Ontario participated in further development of the national AQHI by providing air quality data to the federal government.

The federal government started piloting the AQHI in 2007 in select urban communities in Ontario, in partnership with MECP. Meanwhile, the AQI was reported across the province. Conflicting air quality messages between Ontario’s AQI and the federal AQHI were observed during some poor air quality events.

Public Health Ontario reviewed the AQI and the AQHI on behalf of Ministry of Health and Long-Term Care with MECP’s concurrence. On January 30, 2013, Public Health Ontario released a report titled “*Review of Air Quality Index and Air Quality Health Index*”. The Public Health Ontario report maintained a neutral position in comparing the two indices and did not recommend whether Ontario should adopt the AQHI.

In partnership with the federal government, Ontario developed a new Air Quality Health Index Plus (AQHI Plus), which is a hybrid index of Ontario’s AQI and the federal AQHI and takes advantages of both indices. This document outlines how Ontario’s modified AQI (mAQI), the federal AQHI, and the AQHI Plus are calculated from hourly concentrations. The advisory program associated with the AQHI Plus is briefly described as well.

### Ontario’s mAQI (1-10+)

* 1. Collect concentration readings for up to two pollutants (O3 and NO2) from air monitoring stations across Ontario. Calculate the 1-hour average concentration of each pollutant at each station and report the values at the end of every hour.
  2. Calculate the mAQI for each station.
     1. To calculate the sub-indices for O3 and NO2, use the formulae found in Table 1 for each station using the 1-hour average.
     2. Select the maximum sub-index from each station for the current hour; store it with the determining pollutant as the station mAQI, and round to the nearest integer.
  3. Calculate the mAQI for each community (mAQI-C).
     1. If hourly concentrations are available for more than one station in one community, calculate the community average concentration of each pollutant by summing the hourly concentrations of all the stations in the community and dividing by the number of stations.
     2. Calculate the sub-mAQI-C for each pollutant using the formulae found in Table 1.
     3. Select the maximum sub-index from the community for the current hour; store it with the determining pollutant as the mAQI-C, and round to the nearest integer.



Figure 1. Calculating mAQI values for stations and communities

Table 1. mAQI formulae

| **Pollutant** | **mAQI Category** | **Concentration Range** | **mAQI Range** | **mAQI Equation** |
| --- | --- | --- | --- | --- |
| Ozone (O3)  Unit: ppb  Average time: 1-hour  Poll. Code: 122 | Good (1-3) | 0 to 50 | 1 to 3.49 | 0.04980 x [O3] + 1.000 |
| Moderate (4-6) | 51 to 80 | 3.5 to 6.49 | 0.1031 x [O3] -1.758 |
| Poor (7-10) | 81 to 149 | 6.5 to 10.49 | 0.05868 x [O3] + 1.747 |
| Very Poor (>10) | > 149 | > 10.49 | 0.05868 x [O3] + 1.747 |
| Nitrogen Dioxide (NO2)  Unit: ppb  Average: 1-hour  Poll. Code: 36 | Good (1-3) | 0 to 110 | 1 to 3.49 | 0.02264 x [NO2] + 1.000 |
| Moderate (4-6) | 111 to 200 | 3.5 to 6.49 | 0.03360 x [NO2] - 0.2291 |
| Poor (7-10) | 201 to 524 | 6.5 to 10.49 | 0.01235 x [NO2] + 4.017 |
| Very Poor (>10) | > 524 | > 10.49 | 0.01810 x [NO2] + 1.000 |

### The federal AQHI (1-10+)

* 1. Collect concentration readings for three pollutants (O3, PM2.5, and NO2) from air monitoring stations across Ontario. Calculate the 1-hour average concentration of each pollutant at each station and report the values at the end of every hour.
  2. Average the concentration of each pollutant over the past 3 hours for each station. If 2 readings are missing over the past 3 hours, then set the station average to missing.
  3. Calculate the AQHI for each station.
     1. If a 3-hour average is available for one station, calculate the sub-AQHI for each pollutant using the following AQHI formulae for each station applying the 3-hour average.

Sub-AQHI for O3:

Sub-AQHI for PM2.5:

Sub-AQHI for NO2:

* + 1. Set the AQHI to the sum of the sub-AQHIs and round to the nearest integer. Store the AQHI of each station. If the AQHI is less than 0.5, then set the value to 1.
  1. Calculate the AQHI for each community (AQHI-C).
     1. If a 3-hour average is available for more than one station in one community, calculate the community average concentration of each pollutant. The community average concentration of each pollutant can be determined by summing the 3-hour concentration averages from all the stations in the community and dividing by the number of stations.
     2. Calculate the sub-AQHI-C for each pollutant using the above-mentioned AQHI formulae applying the community-averaged 3-hour readings. Set the AQHI-C to the sum of the sub-AQHI-Cs and round to the nearest integer. Store the AQHI-C of each community. If the AQHI-C is less than 0.5, then set the value to 1.



Figure 2. Calculating AQHI values for communities and stations

### Ontario’s AQHI Plus (1-10+)

* 1. For each station and each community, select and store the mAQI and AQHI rounded to the nearest integer.
  2. Compare the mAQI and the AQHI for each station and community. Always use the AQHI value for the AQHIPlus, except when the mAQI is greater than 6 and greater than the AQHI or when the mAQI is greater than 6 and the AQHI is missing; then use the mAQI value instead.
  3. Store the hourly AQHI Plus with the determining reason (AQHI or mAQI) for each station and community.



Figure 3. Calculating AQHI Plus values

### Associated Advisory Program

* 1. Environment and Climate Change Canada forecasts AQHI Plus numeric values using near-real-time measurements and air quality forecast models.
  2. If, according to the 37-hour AQHI Plus forecast, the AQHI Plus is expected to be in the “high risk” category for ≥3 hours (persistent), issue a Smog and Air Health Advisory to the public.
  3. If the “high risk” air quality condition is expected to last for 1 or 2 hours, issue a Special Air Quality Statement to the public.
  4. Otherwise, take no action.



Figure 4. Issuing an air quality alert

### References

* 1. Ontario Ministry of the Environment. 2013. Air Quality in Ontario – Report for 2011. PIBS 9196e.
  2. Chen, H. and R. Copes. 2013. Review of Air Quality Index and Air Quality Health Index. Public Health Ontario.
  3. Mignacca, D., Fraser, D., Yap, D. and Fudge, D. 1991. A Guide to the Ontario Air Quality Index System. Ontario Ministry of the Environment.
  4. Stieb, D.M., Burnett, R.T., Smith-Doiron, M., Brion, O., Shin, H.H. and Economou V. 2008. A New Multipollutant, No-Threshold Air Quality Health Index Based on Short-Term Associations Observed in Daily Time-Series Analyses. *J. Air & Waste Manage. Assoc.* **58**:435–450